3.6 WATER QUALITY

3.6.1 Introduction

Water quality is measured by many parameters. The physical properties and chemical constituents of water serve as the primary means for monitoring and evaluating water quality. Forest practices have the greatest potential effect on the following water parameters: 1) stream water temperature; 2) sediment-related water quality parameters such as turbidity; and 3) pesticides/herbicides. The Forest Practices Rules must comply with the Clean Water Act to meet state water quality standards for surface waters and groundwater. Moreover, they must provide for adequate water quality protection for fish and wildlife habitat. The impacts of forest practices to water are also described in Section 3.2 (Sediment) and Section 3.3 (Hydrology). This section briefly describes the issue of water quality, and the current water quality status of lands subject to FPRs. It closes with cross-references to other sections that evaluate the potential water-related environmental consequences of the alternatives.

3.6.2 Affected Environment

3.6.2.1 Surface Water

Wet Pacific weather systems combined with the rain shadow effect produced by the Cascade Mountains, produce heavy rains on the western slopes of the Cascades and drier conditions east of the Cascades. As a result, a myriad of surface water conditions occur in Washington state. Literally all forested lands in Washington have distinct surface water features, ranging from small, intermittent streams to the very large Columbia and Snake rivers. Most of these rivers and streams support complex aquatic ecosystems, including stocks of endangered Pacific salmon and numerous other aquatic communities. Many of the major rivers and streams on the west side of the Cascades and the east side of the Olympics drain into Puget Sound, a complex and valuable marine resource to Washington state.

3.6.2.2 Groundwater

Groundwater depths, volumes, uses, and vulnerability to contamination vary considerably across Washington state. Groundwater provides drinking water for 60 to 70 percent of the population throughout the state. In large areas east of the Cascade mountain range, 80 to 100 percent of available drinking water is obtained from groundwater resources. In addition, some areas of the state, including most of Island and San Juan counties, rely solely on groundwater sources for potable water. As a whole, over 95 percent of Washington's public water supply systems use groundwater as their primary water source (U.S. EPA, 1999).

As noted above, certain areas of Washington state acquire 100 percent of their potable water from groundwater sources (sole-source aquifers). Arid areas east of the Cascades as well as islands in the Puget Sound region are particularly dependent on sole-source aquifers. State and federal programs and regulations that address groundwater quality and nitrate contamination (e.g., the Safe Drinking Water Act) mandate the routine monitoring of public supply wells to protect groundwater quality. The FPRs do not directly address protection of sole-source aquifers, however, the widespread use of forest chemicals in Washington state is a concern to sole-source aquifer users.

Groundwater is also often connected directly or indirectly to rivers, streams, lakes, and other surface water bodies, with the exchange of water occurring between these resources. In some areas of the state, groundwater contributes significantly to the base-flow of streams and summer-flow to lakes. Depending on the geologic and hydrologic conditions of the aquifer, contaminated groundwater may discharge to surface areas within one day, or may take as long as a thousand years or more (U.S. EPA, 1986). In addition, surface waters can contribute to groundwater recharge. Impacts on groundwater, therefore, also can lead to impacts on surface waters (and vice versa) as well as to aquatic organisms.

3.6.2.3 Water Quality Parameters for Surface Waters

Temperature

Stream temperature is influenced by many factors including latitude, altitude, season, time of day, flow, channel width and depth, groundwater flow, stream shading from topography or vegetation, and coastal fog (MacDonald et al., 1991). Temperature plays an integral role in the biological productivity of streams. Aquatic life is the beneficial use of the water that is most sensitive to water temperatures. Salmonids and some amphibians appear to be the most sensitive to water temperatures. Thus, they are used as indicator species regarding water temperature and water quality. Salmonid temperature requirements can vary by species and lifestage (Bjornn and Reiser, 1991; Hicks, 2000). However, in general, juvenile salmon and trout are susceptible to sublethal adverse effects when the average stream temperature is above about 59°F (Hicks, 2000). Bull trout may be susceptible when average temperatures are greater than about 50°F. The upper lethal temperature for salmonids common in the Pacific Northwest ranges from 73 to 79°F (Bjornn and Reiser, 1991). The preferred range for most salmon and trout is 54 to 57°F (Bjornn and Reiser, 1991).

Stream water temperature is regulated by heat exchange between the stream water and the aerial and subsurface conditions. Heat energy is transferred to and from streams by direct solar radiation (short wave), long-wave radiation, convective mixing with air, evaporation, conduction with the stream bed, and advective mixing with inflow from groundwater or tributary streams (Beschta et al., 1987; Sullivan et al., 1990). Streams exhibit a natural warming trend as water flows from headwaters to the sea (Sullivan et al., 1990). However, changes in environmental conditions along a reach can modify temperatures beyond the normal trend. In small- to intermediate-size streams of forested regions, incoming solar radiation represents the dominant form of energy input to streams during the summer, with convection, conduction, evaporation, and advection playing relatively minor roles (Brown, 1980; Beschta et al., 1987; Sullivan et al., 1990). In larger streams, the effects of riparian shading and advective mixing diminish and evaporative heat-loss processes increase. In small streams, groundwater discharge may also be important where it provides a large percentage of the overall discharge, particularly in the summer months during low flows.

Brosofske et al. (1997) suggested that groundwater and stream temperatures could increase due to heating of upslope soils in clearcuts. In their study, stream temperatures were correlated with shallow (4 inches) upslope soil temperatures. However, the Brosofske et al. (1997) study was focused on microclimate gradients in riparian zones rather than water heating and watershed hydrology; no measurements of interflow (horizontal movements of water above the water table) and groundwater temperatures were taken. St. Hilaire et al. (2000) incorporated interflow in their mechanistic stream-heating model. Their unverified modeling predictions suggested that less than a 0.4°C increase would occur during a tropical storm if 50 percent of the watershed were harvested. Overall, the magnitude of effects of upslope clearcuts on stream temperatures, if any, is uncertain.

Sediment

Two of the most common water quality parameters measured and monitored for sediment are suspended sediment and turbidity. Both are related to sediment delivery and transport in hydrologic systems. Streams that exceed water quality objectives for sediment would have high suspended-sediment delivery rates and/or turbidity. Suspended sediment is the portion of the sediment load suspended in the water column. The grain size of suspended sediment is usually less than one mm in diameter (clays and silts) (Sullivan et al., 1987). Turbidity refers to the amount of light scattered or absorbed by a fluid and is measured in nephelometric turbidity units (NTU). In streams, turbidity is usually a result of suspended particles of silts and clay, but also organic matter, colored organic compounds, plankton, and microorganisms.

Biological effects of increased turbidity may include a decrease in primary productivity of algae and periphyton due to the decrease in light penetration (see Section 3.8). Declines in primary productivity can adversely affect the productivity of higher trophic levels such as macroinvertebrates and fish (Gregory et al., 1987). Siltation and turbidity have also been shown to affect fish adversely at every stage in their life cycle (Iwamoto et al., 1978); spawning and incubation habitats are most directly affected (Spence et al., 1996). Deposited sediments tend to have a greater impact on fish than suspended sediment.

Pesticides

Pesticides used in forest management include a wide variety of chemicals introduced to the forest environment with the intent of controlling or halting the proliferation of nuisance organisms. Pesticides are commonly grouped according to one of three target organisms: plants (herbicides), insects (insecticides), and fungi (fungicides). In general, pesticide application rates on forested lands are fairly infrequent, with roughly one to two applications every 40 to 60 years (Ecology 1993). The effects of individual pesticides usually are determined by the active ingredients. In addition, prior to application, most pesticides are combined with a surfactant (i.e., a surface-active agent) or other adjuvant (i.e., a pharmacological agent added to increase or aid the pesticide's effect) to control and improve the desired effect. Although these additives typically present lesser threats to the environment than the active ingredients in the pesticides, their impacts can be significant, and in some cases the impacts are greater than those associated with the active ingredients.

Pesticides used in the forest environment can become water contaminants if they are transported to surface waters or groundwater. Transportation to surface waters would most likely occur through wind drift; however, heavy rains can result in pesticide transport in stormwater runoff or through contaminated soil erosion. Pesticides can also be directly applied to surface waters by overspray and spills. Groundwater contamination can occur through contaminated surface water recharge and through the direct transport of pesticides from the soil surface by rainwater. Most pesticides that have been detected in streams and groundwater are present at very low concentrations, usually well below regulatory drinking water criteria (USGS, 1996a,b,c, 1997b). However, some pesticides have been detected at concentrations that exceed the more restrictive guidelines for the protection of aquatic life (freshwater chronic criteria) or health advisories for drinking water (USGS, 1996c; Ecology, 1993). Although studies focused specifically on forestry applications have found violations of applicable water quality standards resulting from chemical applications, these violations usually resulted from the lack of spray buffers or from applications over dry or ephemeral streams (Neary and Michael, 1996; Ecology, 1993). Finally, although low levels of pesticide contamination in surface water and groundwater have been found throughout Washington state, the source of the contamination (e.g., forest applications, agriculture, urban activity) is difficult to identify and cannot be linked directly to forest applications, unless no other possible sources exist.

3.6.2.4 Regulatory Background

The Forest Practices Rules must comply with the Clean Water Act to meet state water quality standards for surface waters and groundwater (Table 3.6-1). Water quality standards are set to provide for the protection of beneficial uses such as public water

Table 3.6-1. Washington State Water Quality Standards for the Major Non-Chemical Parameters of Concern[1/]

Water Quality Parameter	Washington State Standard (Class AA, Excellent)	Washington State Standard (Class A, Good)
Temperature	Shall not exceed 16.0°C due to human activities. When natural conditions exceed 16°C, no temperature increase greater than 0.3°C is allowed. Incremental temperature changes from nonpoint source activities shall not exceed 2.8°C.	Shall not exceed 18.0°C due to human activities. When natural conditions exceed 18°C, no temperature increase greater than 0.3°C is allowed. Incremental temperature changes from nonpoint source activities shall not exceed 2.8°C.
Sediment	In regard to forest practices, implementation of approved BMPs will meet narrative water quality criteria such as support characteristic water uses, aesthetic values, etc.	Same as AA.
Turbidity[2/]	Shall not exceed 5 NTU (nephelometric turbidity units) over background when the background level is 50 NTU or less, nor increase more than 10% of background when the background level is 50 NTU or more.	Shall not exceed 5 NTU over background when the background level is 50 NTU or less, nor increase more than 10% of background when the background level is 50 NTU or more.

[1/] New water quality standards have been proposed and are currently in a draft status. The new standards for temperature would be lower and more specific to fish populations (DOE, 2001).

[2/] Nephelometric turbidity units are the measurement units of turbidity using a nephelometer (light reflected by particles in suspension at a right angle to the original source).

supplies, aquatic habitat, and recreation. The Forest Practices Act of 1974 authorizes the adoption of regulations establishing water quality standards for forest practices. Forest practices rules pertaining to water quality protection were co-adopted by the Forest Practices Board and the Department of Ecology. All other forest practices regulations are adopted by the Forest Practices Board.

ESHB 2091 changes Ecology's role in order to decrease duplication in state government. Ecology no longer has to go through the process of co-adopting water quality related Forest Practices Board rules. The Ecology representative on the Forest Practices Board now simply has to concur with the rules prior to adoption by the Forest Practices Board.

3.6.2.5 Existing Water Quality

Currently, Washington has 643 water bodies—lakes, streams and estuaries—that have been identified as impaired, of the 1,099 for which data have been collected. The 643 water bodies represent only about two percent of all the waters in Washington (Washington Department of Ecology, 1998). The water bodies measured were generally those that have a history of pollution. It is possible that other unmeasured water bodies also exceed water quality standards at some time. In 1996, the Department of Ecology listed 611 water bodies. The number of water bodies on the 1998 list increased by 32 over the 611 on the 1996 list.

The primary water quality problem on forest lands throughout the state is temperature which also happens to be the most prominent water quality problem for the state's water bodies. There is no readily available information on the number of impaired water bodies on forest lands throughout the state. Elevated water temperature generally occurs in areas where timber harvest or development has removed trees, taking away shade, which is necessary to keep the water temperature low and healthy for fish. Other problems include erosion from road building, construction, and agriculture, which increases sediment in streams.

3.6.3 Environmental Effects

3.6.3.1 Evaluation Criteria

Water Temperature

Many factors can influence stream temperature such as shade, air temperature, and groundwater inflow. Forest practices can reduce canopy cover near streams. The evaluation criteria for stream water temperature is the protection of stream-side shade to maintain ambient stream temperature. As discussed in Section 3.4.3.1., a no-harvest buffer width of 0.75 of a site-potential tree will be used as the criterion to evaluate the effectiveness of riparian management zones to maintain shade, and thus stream water temperature for streams greater than 5 feet in width (Spence et al., 1996). For streams less than 5 feet in width, the evaluation criterion will include the protection of hyporheic zones (i.e., areas where groundwater enters a stream), seeps, and sensitive sites in combination with maintenance of a 50-foot no-harvest RMZ that provides full shade protection of small streams (Broderson, 1973).

Sediment

Timber harvest activities such as road building and timber yarding may increase sediment input into streams (see Section 3.2, Sediment, for detailed discussion). Fine sediment can impair municipal and agricultural use of water, affect bed material size, and alter the quantity and quality of habitat for fish and benthic invertebrates. The evaluation criterion for sediment-related water quality parameters is the overall reduction in sediment delivery to streams from management activities. These include reduction in chronic erosion sources such as surface erosion and episodic sediment such as landslides from BMPs for timber harvest, road construction, road use, road maintenance, and road abandonment.

Pesticides

Pesticides have the potential to contaminate surface waters and groundwater depending on the amount of pesticides applied, the application technique, and the environmental conditions under which they are applied (e.g., ambient wind speed, soil runoff potential, storm frequency; Ecology 1993; Neary and Michael 1996). The evaluation criteria for pesticide applications focus on how well the Forest Practices Rules protect water resources from contamination resulting from pesticide applications (e.g., spray drift, runoff, erosion, seepage to groundwater). In addition, the evaluation criteria take into account how well the alternatives protect riparian plants from damage caused by pesticide applications. Finally, the criteria also consider the potential impacts on fish and aquatic wildlife resulting from contamination of water resources.

3.6.3.2 Effects on Water Temperature

Alternative 1

Alternative 1 would result in a low to moderate risk of stream temperature increases along Type 1, 2, and 3 waters and a high risk along Type 4 and 5 waters.

Under the current rules, Type 1, 2, and 3 waters would receive some type of shade protection regardless of RMZ width. As part of the RMZ, a shade requirement in the forest practices rules must be maintained before any harvest activity can occur within the RMZ. The shade rule is based upon elevation of the stream and the water quality classification of the stream (A or AA; see discussion above). The shade rule reflects the fact that lower-elevation streams require more shade and higher elevations require less shade. The shade rules are meant to achieve state water quality standards, which include a small temperature increase. The shade rules decrease the allowable amount of trees that can be removed from RMZs by requiring specified levels of canopy closure over streams at different elevations. RMZ widths at lower elevations tend to be larger to meet the requirements of the shade rule.

On the westside, the minimum RMZ width of 25 feet on Type 2 and 3 waters (Type 1 waters have much wider buffers due to SMZs) does not meet the 0.75 SPTH required for complete protection for any site class (Figure 3.4-3). For each stream type, RMZ buffer widths can vary between the minimum and maximum values, depending on the extent of wetland vegetation or the width needed for shade (based on elevation in regard to meeting water quality standards). For Type 4 and 5 waters, RMZs are not required under certain conditions and, in this case, would not exceed 25 feet. Therefore, RMZs for Type 4 and 5 streams do not meet the 0.75 SPTH required for complete protection. This is important because Type 4 and Type 5 waters comprise approximately 80 percent of the drainage network (see Appendix C).

On the eastside, most RMZ widths along Type 1, 2, and 3 streams do not meet the 0.75 SPTH requirement. The few exceptions are primarily where maximum RMZs are applied to low site classes. However, minimum RMZ widths of 30 feet do not meet the 0.75 SPTH required for complete protection for any site class (Figure 3.4-3). Similar to the westside, the RMZ buffer width can vary between the minimum and maximum values, depending on the extent of wetland vegetation or the width needed for shade.

For Types 4 and 5 waters, RMZs are not required except for site-specific conditions and in this case would not exceed 25 feet. The lack of RMZs on Type 4 streams does not meet the 50-foot RMZ criterion for full shade protection. However, shade is provided to these streams from understory and slash. Caldwell et al. (1991) documented temperature increases in harvested Type 4 waters of 2^{o}C to 8^{o}C on several westside streams. Although in many cases the water quality temperature criteria were met, the increases observed were still violations of the 2.8^{o}C increase allowed for nonpoint source activities. However, where a harvested Type 4 stream flows into a Type 3 stream, the temperature increases in the Type 4 stream were negligible approximately 150 meters downstream of the confluence (Caldwell et al., 1991). In addition, Zwienecki and Newton (1999) found that streams returned to normal temperatures within 500 feet after accounting for a stream's natural downstream warming trend. Furthermore, there is no protection of seeps and hyporheic zones for Type 4 waters. In conclusion, there is a high risk of temperature increases along harvested Type 4 waters, particularly in lower elevation watersheds less than 1,640 feet in elevation.

> Alternative 2 would result in low risk of reduced stream shade along Type S and F streams. There would be moderate to high risk of reduced stream shade along Type N streams, which would likely affect temperature in these streams. The effect of temperature increases in nonfish-bearing streams on downstream fish streams is uncertain and could be important in watersheds with a high degree of past harvest or already elevated stream temperature.

The shade provided by RMZs under Alternative 1 is further compromised by the reduction in canopy from allowable harvest within the RMZ, because the shade rule only protects a portion of the trees that provide overhead canopy directly above the stream. Alternative 1 does not meet the protection requirements for maintaining stream temperature along Type 1, 2, and 3 waters, resulting in a low to moderate risk of stream temperature increases. Type 4 and 5 waters are at high risk of stream temperature increase, because there are no buffers along Type 4 and 5 streams.

Alternative 2

WESTSIDE

Under Alternative 2, the stream typing would increase the protection of shading provided to the entire drainage network, because more streams would receive some type of buffer; approximately 66 percent of the Type 4 streams that become Type F streams would receive some buffer to provide shade compared to Alternative 1. Under Alternative 2, the nominal RMZ widths for Type S and F streams exceed the criteria to provide complete shade, using both 100-year and 250-year SPTHs (Table 3.4-1), but some level of harvest would be allowed within the inner and outer zones.

At least 50 percent of the distance along Type N_p streams would receive a 50-foot no-harvest buffer. Seeps and sensitive areas, such as hyporheic zones, would also receive protection from forest practices with 50-foot no-harvest buffers. In the areas where two Type N_p streams meet (at initiation points), a 56-foot radius no-harvest buffers would

also be established. In addition, where an N_p stream meets a Type F or Type S stream, a 50-foot no-harvest buffer would be required for the first 500 feet upstream of the confluence with the Type F or S stream. These buffers should maintain stream water temperatures in N_p streams. However, there may be a low to moderate risk of temperature increases at the mouth of N_p streams containing reaches with no buffers. However, any potential increases in stream temperatures is expected to be attenuated downstream within 500 feet, when the water flows through shaded no-harvest RMZs.

Type N_S streams would not likely be adversely affected because these streams tend to be dry during the warmest summer months when the beneficial uses of the waters are most vulnerable to warming. However, Type N_s streams that may have water present during this time may not have adequate shade from overstory trees to maintain stream temperature because there would be no buffers required along these streams. Shrubs and debris in the streams may provide adequate shade; but, because of this uncertainty, there is a high risk of water temperature increases in Type N_S streams with flowing water during the summer months.

There are no data from the scientific literature that conclusively demonstrates that the combination of a no-harvest zone with a selective harvest zone out to 0.75 SPTH will provide complete shade protection. In general, the no-harvest portions of RMZs and the implementation of the shade rule would provide a higher level of protection and increase shade in areas where applied. Overall, the RMZ effectiveness to provide shade to Type S and F streams within this alternative is high (see Section 3.4, Riparian Habitats, for a more detailed discussion). RMZs along Type S and F waters are adequate to maintain shade; however, potential increases in water temperature may occur along Type N_s and N_p streams. The potential cumulative effects of temperature increases in Type N_p streams delivering to Type S and F streams is uncertain, but could be important in watersheds with a high degree of past harvest or a history of elevated temperatures. This is a priority research topic under Alternative 2's adaptive management program.

EASTSIDE

Under Alternative 2, RMZ buffer widths exceed the width recommended in the literature for shade for Type S and F streams (Figure 3.4-3). Along Type S and F streams the 30-foot no-harvest zone adjacent to the stream bank (or CMZ) combined with the inner zone's selective harvest prescription (out to 0.75 SPTH) should protect most if not all of the RMZs capacity to shade the stream (see Section 3.4, Riparian Habitats, for a more detailed discussion). In addition, the shade rule and bull trout overlay would require more trees to remain in the inner zone, primarily at lower elevation sites. The protection of shade would maintain stream water temperatures.

For Type N_P streams, sensitive sites would be buffered with either a partial cut buffer for the partial cut strategy or 50 no-harvest buffer for the clearcut strategy. The 50-foot partial cut strategy RMZ does not provide complete protection of shade. However, these buffers should protect hyporheic zones and seeps and provide sufficient shade with understory vegetation to protect stream water temperatures. For the clearcut strategy, the 50 feet of no-harvest protection would only be provided on one-third of the N_p stream. There is a low to moderate risk of temperature increases for segments of unbuffered N_p streams. However, stream temperatures that may increase would be reduced downstream when the water flows through an RMZ. In addition, sensitive sites are also protected from harvest which protect groundwater seeps and hyporheic zones. N_s streams would not likely be adversely affected, because these streams tend to be dry during the warmest summer months when the beneficial uses of the waters are most vulnerable to warming. However, Type N_s streams that may have water present during this time may not have adequate shade from overstory trees to maintain stream temperature because there are no buffers required along these streams. Shrubs and debris in the streams may provide adequate shade; but, because of uncertainty, there is a moderate to high risk of water temperature increases in N_s streams with flowing water during the summer months.

Alternative 3

Overall, for all streams on both the eastside and westside, most if not all shade is protected (Figures 3.4-7 and 3.4-8). In general, the expansive no-harvest RMZs provide a higher level of protection eliminating risk of shade reduction. Alternative 3 provides the most protection of shade when compared to all other alternatives for all streams. Stream water temperatures would be maintained.

3.6.3.3 Effects on Sediment

Alternative 1

> Alternative 1 would result in a high risk of sediment-related impacts to streams.

Under Alternative 1, the current FPRs provide prescriptive based BMPs that have been approved by Department of Ecology. However, as many studies (see Section 3.2, Sediment) have shown, the implementation of BMPs does not always reduce water quality-related impact from sediments (see Rashin et al., 1999). As discussed in Section 3.2 and Appendix E (Forest Roads), the rules under Alternative 1 may decrease sediment as BMPs are implemented, but the cumulative effects of the BMPs and the paucity of road maintenance plans present a high risk of sediment delivery to streams.

Alternative 2

> Alternative 2 would result in a moderate risk of sediment delivery in the short term (next 15 years) and a low to moderate risk of sediment delivery to streams in the long term; this conclusion has a moderate degree of uncertainty.

Under Alternative 2, the cumulative effect of the implementation of RMAPs, BMPs, and specific road management, use, maintenance, and construction guidelines in the Board Road Manual, RMZs and ELZs on all perennial and intermittent streams, and greater environmental review of practices on potentially unstable slopes, should substantially reduce sediment delivery to streams compared to Alternative 1. The effect in sediment reduction will occur over time as the RMAPs are implemented and completed by 2015. In addition, a greater percentage of the landscape will not experience future ground disturbance because of no-harvest or ELZ protections.

Until the completion of the RMAPs, road related generated sediment from surface erosion and mass wasting will continue at lower rates than Alternative 1. In conclusion, sediment reduction will occur over time, with the greatest reduction occurring by 2015 or later.

Alternative 3

> Alternative 3 would result in a moderate risk of sediment delivery in the short term (next 10 years) and a low risk of sediment delivery to streams in the long term; this conclusion has a moderate degree of uncertainty.

Under Alternative 3, the reduction in sediment will be greater overall and occur in a shorter timeframe. The shorter timeframe for implementation of RMAPs by 2010, the no-net-increase in roads, and the more rapid maintenance and abandonment of orphan roads will reduce sediment delivery to streams to a greater degree than Alternative 2.

3.6.3.4 Effects of Pesticides

The effects of forest chemicals are discussed from a water source perspective: surface waters, groundwater, and sole-source aquifer. The following paragraphs focus on the differences among the three alternatives pertinent to the issues of forest pesticide use and application, with particular emphasis on forest pesticide impacts on water resources (surface waters, groundwater, and sole-source aquifers).

In addition, it is important to note that several other laws and regulations, aside from the forest practices rules, apply to the conduct of forest practices (WAC 222-50). In particular, all alternatives are subject to WAC 222-16-070 (pesticide uses with the potential for a substantial impact on the environment), which requires all aerial applications to first go through a site-specific evaluation to obtain approval for all aerial applications. This preliminary process addresses the available information on the toxicity of the specific pesticide and the potential impacts of the proposed applications. The regulations imposed by this preliminary analysis are highly situation specific. In the most extreme circumstances, the required "key for the evaluation of site-specific use of aerially applied chemicals" (WAC 222-16-070) may identify the application as "Class IV-special" which in turn, would trigger additional environmental precautions and documentation (WAC 22-16-50). The important consideration is that the forest practices rules are not the single means of environmental protection for pesticide applications. Thus, the analysis presented in this EIS focuses on an evaluation of each alternative with the purpose of making comparisons among the three alternatives and is not intended to include a discussion of all applicable forest chemical regulations.

Alternative 1 would result in a risk of surface water contamination resulting from adverse weather conditions, runoff or erosion of highly mobile or persistent pesticides applied near surface waters, and/or inappropriate equipment use and selection.

Alternative 1

SURFACE WATER IMPACTS

The allowance of hand application of pesticides within the RMZ should not result in overspray of pesticides to the degree that the pesticides would directly enter surface waters. However, application of highly persistent pesticides, or pesticides with high mobility, could result in measurable surface water contamination through localized erosion or storm runoff. The overall impact would be situation- and chemical-specific, depending on the specific chemical properties as well as the timing, duration, and extent of contamination. In general, because of the slow surface and subsurface runoff from forested lands and the relatively infrequent pesticide applications, most pesticide applications in the RMZ are not expected to result in significant impacts on water quality.

The 50-foot buffer required for aerial applications on all Type 1, 2, and 3 waters and flowing portions of Type 4 and 5 waters does not provide sufficient protection against the risk of pesticides entering surface waters. Wind conditions favoring atmospheric drift toward a given surface water could result in a direct application of pesticides to the surface water. Alternative 1 does not include any special provisions or modifications for pesticide application based on weather conditions or equipment (e.g., wind speed, application height, nozzle type, or droplet size). Variations in wind conditions, droplet size, air shear (a function of nozzle angle and air speed), nozzle height, and boom length all have a significant influence on pesticide spray drift (SDTF 1997a; Ecology 1993). By not accounting for these variations, Alternative 1 presents a risk of surface water contamination caused by spray drift, adverse weather, or inappropriate equipment selection and use. Although the entry of pesticides into surface waters does not necessarily result in significant impacts (e.g., very low levels of pesticide contamination may not even be measurable), Ecology (1993) found a 50-foot buffer to be partially effective to ineffective at meeting applicable water quality standards, Forest Practices Rule requirements, and certain product label restrictions.

In addition, the application of pesticides to dry portions of Type 4 and 5 waters and other ponds and sloughs could result in high in-stream concentrations if future runoff returns flow to the dry streams (Ecology 1993). Research has shown instances where applications over dry channels resulted in very high in-stream concentrations of chemicals. The results were generally temporary but significant enough to cause adverse impacts on water quality and aquatic organisms (Neary and Michael 1996; Ecology 1993). Because none of the alternatives provide any greater protection of dry streambeds, the impacts would be the same under all alternatives.

When applying pesticides using power equipment from the ground, the 25-foot buffer required for all typed waters (excluding dry Type 4 and 5 waters) and all Type A and B wetlands should adequately protect surface waters from receiving significant pesticide overspray. However, as with the hand and aerial applications, the 25-foot buffer does not provide a high level of protection from highly mobile or highly persistent pesticides that may be transported to the surface waters through erosion or storm runoff. On the other hand, the slow runoff from forested lands, relatively infrequent application of pesticides, and generally low toxicity of most pesticides are likely to limit surface water contamination. Hand application of pesticides within the wetland management zone should not result in significant impacts to surface waters, provided that those pesticides are only applied to specific targets and the required application rates are not exceeded. The 200-foot buffer required for applications around residences (unless the application is acceptable to the resident or land owner) designed to limit contamination of residential land in general, should also provide incidental protection of any surface waters near residences. This assumes that applications that are allowed by the land owners would still be subject to the applicable buffers for any surface waters on the property. On the other hand, the smaller 100-foot buffer incorporated to protect agricultural land from contamination could result in spray drift of pesticides to the agricultural land that in turn could allow the transport of forest pesticides to surface waters. Given the considerable level of pesticide applications on agricultural land in general (e.g., by the land owners for agricultural uses), the potential contribution from spray drift of forest applications is expected to be small and is not considered a significant threat to surface water contamination.

Any leaks, drips, and spills of pesticides could contaminate forest soils. The potential impacts of an accidental spill are highly dependent on the effectiveness of the required containment and cleanup procedures. If effective safety and cleanup measures are not implemented and contaminated soils erode, the contaminants could be passed to downstream waters.

Finally, possible impacts on surface waters could occur through contaminated groundwater flow to surface waters. The extent of these impacts is difficult to predict but depends on the degree of contamination of the groundwater, the volume of water exchanged, the length of time between contamination of groundwater and contact with surface water, and the persistence and mobility of the pesticide in question.

Overall, pesticide applications under Alternative 1 present a risk of surface water contamination and may result in impacts on surface waters. For further details on the water quality impacts associated with forest pesticide applications, see Appendix J, Forest Chemicals.

GROUNDWATER IMPACTS

Because all alternatives are subject to specific provisions for the protection of groundwater having a high susceptibility for contamination (WAC 222-16-070), statewide application of forest pesticides should not result in significant impacts on groundwater quality.

Alternative 1 includes provisions to limit groundwater contamination resulting from forest pesticide applications. Groundwater protection is provided under WAC 222-16-070 (pesticide uses with the potential for a substantial impact on the environment), where the Forest Practice Rules require an evaluation of site-specific use of aerially applied pesticides. However, localized groundwater impacts could also occur through contaminated surface water recharge to groundwater. The extent of these impacts is difficult to predict but depends on the degree of contamination of the surface water, the volume of water exchanged, and the mobility and persistence of the chemical contaminant.

The likelihood that a given pesticide would impact a groundwater aquifer depends in part on geologic and hydrologic conditions that vary considerably across the state. Local conditions determine how rapidly groundwater moves, whether it is connected directly or indirectly to surface waters and how groundwater withdrawals affect surface waters, the depth of the water below the soil surface, and how effectively soils attenuate or filter out chemical contaminants (U.S. EPA, 1986). This complex interaction between soil and water makes it difficult to predict the likelihood and extent of groundwater contamination.

Because Alternative 1 provides provisions for groundwater protection, statewide application of forest pesticides should not result in significant impacts on groundwater quality. However, groundwater impacts could occur in localized areas with particularly vulnerable aquifers and in areas where highly persistent and mobile pesticides are applied. Likewise, the continual application of forest pesticides to forested lands may contribute to cumulative effects on groundwater quality, the net effects of which are area- or site-specific and somewhat unpredictable. Additional details on the potential impacts to groundwater quality are discussed in Appendix J.

The widespread use of pesticides could lead to groundwater contamination in sole-source aquifers unless adequate protective measures are taken. Alternative 1 does not include any specific provisions for the protection of sole-source aquifers, but does provide for the protection of groundwater having a high susceptibility for contamination. In general, Alternative 1 is not expected to result in significant impacts on sole-source aquifers. To date, there are no data that indicate that the existing forest pesticide applications (Alternative 1) have resulted in significant impacts to sole-source aquifers, therefore, no significant impacts are expected to occur if the same rules continue to apply. Continuing application of forest pesticides, however, could contribute to cumulative impacts associated with contamination of sole-source aquifers. Appendix J contains additional details on the potential for sole-source aquifer contamination.

Alternative 2

Surface Water Impacts

Additional requirements targeting the protection of surface water resources under Alternative 2, would result in a reduced risk of impacts on surface water and groundwater (through a reduction in exchange with contaminated surface water).

Alternative 2 is similar to Alternative 1 but contains additional requirements targeting the protection of water resources. Alternative 2 includes the implementation of BMPs designed to "eliminate the direct entry of pesticides to water (defined as the entry of medium to large droplets), while minimizing off-target drift" (WDNR, 1999). By recommending variable buffer widths for aerial applications depending on water type, environmental conditions, and the method of application, Alternative 2 would result in a lower risk of water quality impacts compared to Alternative 1. Specifically, by adjusting the buffer widths to suit wind conditions, nozzle types, and application heights, Alternative 2 would reduce the pesticide drift into surface waters compared to Alternative 1 (Washington Department of Ecology, 1993). Buffer widths specified for Alternative 2 also are correlated with the critical management or habitat zones identified for each water type. Therefore, Alternative 2 also would minimize impacts within the RMZs identified for each water type. Moreover, Alternative 2 recommends using the maximum applicable buffer width in situations where the recommended buffer width and recommended offset from the critical surface water zones are different.

Alternative 2 restrictions on ground applications of pesticides with power or hand equipment provide for greater protection of Type S or F waters compared to Alternative 1. Specifically, ground application with power equipment is not permitted within the core and inner zones of Type S and F waters, and hand applications are not allowed within the core zones of Type S or F waters (unless prescribed to meet specific localized requirements). In addition, operators must maintain a 25-foot "no application" buffer strip around Type A or B wetlands and on all sides of all other surface waters, resulting in a greater reduction in the potential for surface water contamination. These increased buffer widths afforded by Alternative 2 would result in less drift and erosive transport of pesticides than under Alternative 1.

Overall, the increased attention given to the required buffer widths under Alternative 2 would reduce the risk of surface water impacts compared to Alternative 1. However, because Alternative 2 still allows for pesticide application over dry segments of some watercourses, some contamination of surface waters is possible if flow returns to the creek soon after the application. Likewise, even with the increased buffer width for most surface waters, Alternative 2 could allow low levels of pesticides to reach surface waters, either directly or through stormwater runoff, soil erosion, and sediment transport. Nevertheless, the net impacts would be less than those expected under Alternative 1.

Groundwater Impacts

Groundwater impacts associated with Alternative 2 are expected to be similar but slightly less than under Alternative 1. Direct impacts on groundwater from pesticide leaching to groundwater aquifers would occur at the same rate under Alternative 2 as with Alternative 1. However, because the increased buffer widths required under Alternative 2 would result in fewer surface water impacts, the likelihood that contaminated surface water would reach and contaminate groundwater (via water exchange with a susceptible aquifer) is also reduced.

Alternative 2 is expected to result in similar but slightly lower impacts on sole-source aquifers compared to Alternative 1. The increased buffer widths required for pesticide applications under Alternative 2 would result in slightly less impact on surface waters resulting in a reduction in the potential for the interaction of contaminated surface water with sole-source aquifers. Overall, however, the impacts are expected to be nearly identical to those described for Alternative 1 (i.e., no significant impacts).

Alternative 3

SURFACE WATER IMPACTS

Increased buffer widths required for hand applications near surface waters under Alternative 3 would result in a reduced risk of contamination of surface waters compared with Alternative 1, and a slightly reduced risk of contamination compared with Alternative 2.

Alternative 3 is nearly identical to Alternative 2, with the exception of three main additions. Under Alternative 3, plants with cultural value would be protected from forest pesticides, hand application of forest pesticides would be prohibited within 50 feet of all typed waters, and forest pesticide applications needed to restore RMZ functions would require an alternative plan. Therefore, surface water impacts from pesticide applications under Alternative 3 are expected to be slightly less than under Alternative 2 and considerably less than under Alternative 1.

The increased buffer required for hand applications near surface waters under Alternative 3 would greatly reduce the amount of pesticides that reach surface waters directly via spray drift compared to Alternative 1, and only slightly reduce the potential for contamination compared to Alternative 2. The recommended 50-foot buffer for hand applications is greater than that required under both Alternatives 1 and 2, with the exception of the core zone buffer on westside Type S and F streams required under Alternative 2 (westside core zone is 50 feet). However, as with Alternatives 1 and 2, low levels of pesticides may reach surface waters through storm runoff, soil erosion, and sediment transport. In addition, alternative plans required for forest pesticide applications when restoring RMZs under Alternative 3 are expected to reduce the amount of pesticides that enter surface waters.

GROUNDWATER IMPACTS

The potential groundwater impacts resulting from pesticide application under Alternative 3 are expected to be nearly identical to the impacts associated with Alternatives 1 and 2. The only difference is that the minor reduction in the potential for pesticide drift to surface waters under Alternative 3 could result in a slight decrease in the level of pesticides reaching groundwater compared to Alternatives 1 and 2 (through a reduction in the exchange with potentially contaminated surface waters, as discussed above).

Alternative 3 is expected to result in similar but slightly lower impacts on sole-source aquifers compared to Alternatives 1 and 2. The increased buffer widths required for pesticide applications under Alternative 3 may result in slightly less sole-source aquifer contamination, through a reduction in the potential for contaminated surface water to interact with and adversely impact groundwater. Overall, the potential impacts to sole-source aquifers are expected to be nearly identical under all alternatives.